SKIAMETRY

STATIC AND DYNAMIC

CONCISE AND PRACTICAL INSTRUCTION IN METHODS OF USING THE RETINOSCOPE—EMBRACING BOTH STATIC AND DYNAMIC PROCEDURES.

BY

WILLIAM B. NEEDLES,

President Needles Institute of Optometry, Kansas City; Scientific Editor "OPTOMETRY."

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INTRODUCTORY.

During the centuries that have elapsed since the invention of spectacles, many ingenious appliances have been devised and methods perfected for the measurement of refractive errors. The philosopher, physicist, mathematician, physician, optician, all have made contributions which the optometrist has utilized alongside the extensive collection of facts dealing with phenomena peculiar to optometry alone in the development of his profession.

One of the mile-stones of the last century was Bowman's discovery of retinoscopy or skiametry. Though this method of measuring the ocular refraction has been proven to be of wonderful value to the profession, it still receives far too little consideration from refractionists in general. This fact is doubtless due to unfamiliarity with the merits of the test and the methods of its application. Notwithstanding all that has been written and said on the subject, it is still not generally comprehended as it should be.

In this hand-book we shall endeavor to present elementary principles and practical helps which may give to the practice work, so necessary to skill, something of system and intelligent purpose.

Men frequently differ on matters concerning which it would seem that there should be no disagreement and skiametry is no exception to the rule. While certain individuals are engaged in earnest disinterested effort to awaken their fellows to appreciation of the

beauties of this method, others there are who openly decry it and strive to discourage its use. The liability of harmful influence upon beginners in optometry from unfriendly criticisms, prompted the writer to make answer in a recent issue of a current publication, "The Bulletin." This article, entitled "Defense of Retinoscopy," is herein republished, with some revision as the writer believes it pertinent to the subject at hand:

"The old controversy between the anti and pro-retinoscopists has recently been revived. In view of the measure of popularity accorded heresy on all other subjects, it is no wonder that one who sets out purposely to create doubt as to the utility of a test involving as many difficulties as retinoscopy, can build up something resembling a case against it and influence many followers.

Unfortunately, it is impossible to confine debate on this subject to those who have honestly and intelligently put forth the effort necessary to proficiency in this method, and however certain may be the assurance that all opposition to retinoscopy is confined to the ranks of those who have never met the requirements of the test, we must, nevertheless, face the attacks as they are made and answer them with logic in the interest of the great majority who seek truth rather than sensationalism.

Criticism of retinoscopy usually resolves into one of the following assertions.

That the subject's accommodation does not remain static when the light is reflected into his eye, hence the findings are not dependable.

To use the mirror proficiently requires practice out of proportion to the results to be attained.

The operator can never prescribe glasses from this test without corroboration with the test case; hence use of the mirror is only a waste of time.

That the exponents of the shadow test themselves do not have faith in it and when brought to a trial of their skill make claims to the need for special equipment as a cloak to cover the inaccuracy of the method.

Let us consider these criticisms in order.

It is a truth of profound importance that the tendency to activity of the ciliary muscle does more to hinder accurate measurement of ametropia than any other single factor. If one can be assured that accommodation is passive throughout his test, he need be under no apprehension as to his prescription. Medical and non-medical refractionists alike, are guilty in repeated instances of prescribing glasses which subsequently prove unsuited to the case, because, in spite of the refractionist's efforts to suppress accommodation, the ciliary muscle sometimes outwits him, and conceals a portion of the error. This applies as much to astigmatism as to axial ametropia. The man who trusts to the test-case examination alone is more liable to these mistakes than any other, inasmuch as they can only be avoided by a thorough analyst and such a one will never confine himself to a single form of test. Optometrists of scientific attainment usually employ the suppression method in both objective and subjective examinations and thus endeavor to control over-accommodation. In a case of accommodative spasm, the test-case examination can no more be relied upon than that made with the retinoscope, until after the ciliary cramp has been relaxed. Sometimes this may be accomplished by carefully manipulating the lenses in either form of test,

but it is usually unwise to prescribe for such cases until after temporary suppression glasses have been worn, or other steps taken to relax the accommodative muscle. To assert that reflection of light into the pupil always induces spasm is exceedingly foolish. There is no reliable basis for such an assumption. Strong light thrown in the eye does induce contraction of the pupil, but pupillary action does not compel ciliary action. Accommodation only occurs in response to a definite need for change of the refractive power of the eye, as in hyperopia, or changing the fixation distance, except in the cases of spasm, and the latter are of nervous origin, being stimulated from nerve centers, which, while associated with the visual centers, are not dominated by them. One who has studied the nervous anatomy of the eyes and brain knows that such cramps come from causes which do not have particularly to do with the method of examination, and may affect the subjective as well as objective test. A sudden flood of light in the eyes does produce momentary annoyance, followed by partial closing of the pupil, whether it comes from reflection by the mirror, or sudden passing from the dark into a lighted room, but this does not alter vision as it would do if the accommodation was affected. The criticism is therefore specious. The man who truly knows his fundamental principles and has acquired skill such as experience alone gives, cannot be misled by arguments based upon half knowledge.

Certain it is, that skill in retinoscopy comes only with long and patient practice; however, no one can honestly decry a test because it demands patience and perseverance of those who master it. It is little short of waste of words to answer such sophistry. Short

cuts to proficiency in any science are doomed to disappointment and it is not otherwise in optometry. It is possible to learn something of piano-playing in a few months, but the artist must devote a lifetime to practice and even then, discovers that perfect mastery of this instrument is impossible. It is just so in the practice of any art worth while. **In optometry the day has passed when one should desire any one single method of examination which alone may be employed in all tests.** The man who finds one method sufficient for all of his needs, has limited requirements, though he may not recognize the fact. Some men become very skillful with a jack-knife and learn to make things with this one instrument which others could not make, perhaps, with a whole kit of tools, but such stunts do not entitle the jack-knife to a place of supremacy over all other implements. The true artisan procures the most complete outfit of tools that can be obtained, then trains himself to the utmost proficiency in the use of them all.

What can the skilled retinoscopist do better than he who uses the test case alone? Suppose we say, nothing. Still we have not discredited, one iota, the shadow test. The very fact that it saves time in every examination justifies it as a method even though no other results were accomplished. Every one knows that as a final analysis of lens power neutralization must be resorted to, yet in every shop the lens measure is employed for all tests that do not involve absolute precision and even for these it is relied upon for approximate findings because it saves time, and, as a rule, is sufficiently accurate. If one merely uses the retinoscope for similar purposes, its value is great, but this is not its chief advantage. Let men who are

not skilled with the mirror scoff as they may, but he who is an expert in both objective and subjective methods, commits fewer errors in his practice, day in and day out, than the one who makes a hobby of either test alone.

A patient having so low visual acuity as to necessitate moving him within a few feet of the test card, may possibly receive proper glasses by the trial-case test alone provided the operator uses care and plenty of time. In far too many cases, however, the true correction will be overlooked because of the subject's inability to accurately report the results attained with the different test lenses. To the retinoscopist, however, these cases are as simple as the neutralization of a strong compound lens.

In addition to the item of saving time and annoyance, it is a demonstrable truth that in cases where the prescription involves high degrees of astigmatism with low visual acuity and perhaps impaired mentality as well, fewer mistakes will be made by the operator who is skilled in objective methods of testing.

As to use of the trial case for final corroboration; every honest practitioner will seek this proof of his test before prescribing, and in doing so, he, by no means, makes confession that his efforts with the retinoscope were fruitless. The professional man should desire the good of his patients; not the vindication of his ideas. The true scientist is eager after truth and rejoices in obtaining it, no matter whence it comes, nor what pet ideas he must renounce in accepting it. Hence, the optometrist would be untrue to himself and exceedingly foolish if he employed retinoscopy as a sort of ceremony, knowing it to be a sham. It is a fact of marked significance, that those optometrists

who use the mirror as a routine test consider the discovery of retinoscopy one of the great contributions to the science of optometry. True, it has its limitations, but no one knows them better than he who is skilled in this method. In fact, no other really does know, because the man who has not trained his hand, eye and brain to the use of the mirror, will find limitations where they do not actually exist. The beginner in this method should not expect absolute precision at the start, but should employ the same common sense with reference to this test that he exercises in other matters. After making his test, he should place the lenses which he finds, in the trial frame, and observe their effect upon the patient's vision. If he finds the latter blurred, he may so change the lenses as to clear it up. If the lenses are too weak, he may strengthen them a trifle. If the cylinders are not in exactly the proper axis, he may adjust them or otherwise alter the lenses as may be required. This does not in any sense occupy the time which would be consumed in making the entire subjective test, and as time goes on, the earnest student of this method will find his prescriptions require less and less change to perfectly adapt them to the patient's needs.

If only one man in a generation attains the necessary skill to prescribe without recourse to the trial case, still all who have employed the mirror will have been well repaid. They will have found their work more enjoyable, their results more satisfactory, and their pride in achievement justly enhanced.

Latent hyperopia frequently prevents the proper correction from one test. In such cases, treatment glasses are sometimes employed to be worn for

periods varying from three days to three weeks, in order to reveal the static refraction. The need for these treatment glasses is as apparent to the retinoscopist as to the test case man, and indications of relaxation are equally apparent.

An advantage of this method which must not be overlooked consists in the fact that the man who employs the retinoscope in every test will also become more skilled in the use of the ophthalmoscope, without which, no optometrist should be permitted to practice his profession. Ocular diseases involving the internal eye should be recognized by the optometrist whenever encountered and the time will come when knowledge of these matters will be demanded of every man before he is admitted to practice. The use of the retinoscope demands much the same general equipment as is required for ophthalmoscopy, hence one is put to practically no extra trouble or expense in preparing to practice this procedure.

Now a word as to equipment. Let no man make the mistake of believing that he can succeed in retinoscopy without the things which all others have found essential. This is a test of precision and it cannot be performed with crude implements. A good dark room, and a proper source of illumination cannot be dispensed with. The test is none too easy with these conveniences, but without them, failure is certain. When the critic sneers at the stress that is laid upon this demand for proper appliances, he is either wilfully or ignorantly trifling with an important truth. The musician cannot produce harmony with an instrument out of tune. The surgeon succeeds just in proportion as he observes care as to the quality and condition of his instruments. No mechanic will

attempt to do good work with inefficient tools, and the optometrist who wishes to learn objective methods is no exception to this rule. The beginner, then, should make no mistake on this point. Success or failure will hinge upon two conditions. One; that his equipment shall be adequate: the other; that he shall be faithful in practice. If he fulfills the requirements the day will surely come when he will smile at the folly of those who speak words of conceit born of ignorance.

NOTES

STATIC SKIAMETRY

CHAPTER I.

Skiametry consists of measuring the ocular refraction by reflecting light from a mirror into the eye and observing the illumination and shadow created therein. This illumination is of primary importance. To the observer it appears to occupy a place in the pupil of the eye under test. Sometimes it is located in but one portion of the pupil leaving the balance in shadow. The slightest tilting of the mirror causes it to change its position. As the illumination is moved out of the pupil, its place is taken by shadow (darkness). It is this shadow which gives this test its name, although in an examination, we observe the illumination as well as the shadow.

Conjugate Foci.—There are a number of matters with which one must be familiar to apply the shadow test successfully. He must understand conjugate foci. He must know that every point on one side of a lens or lens system may be yoked by rays of light with some other point upon the same axis of that lens system. Having one of these conjugate points, he must be able to locate the other. He must employ knowledge of certain facts to inform himself of other facts. The laws governing conjugate foci are of such importance that we will devote brief attention to this subject before proceeding.

Any two points which are so joined by a lens, that light emanating from one will focus at the other, are

said to be **conjugate.** In Fig. 1, light rays emanating from PF, encounter a convex lens and are so refracted by its two surfaces that they leave it parallel to each other. These rays cannot focus at any point nearer than infinity. Therefore, the point PF is the principal focus of the lens and while it really has no conjugate, we assume that its conjugate is at infinity. If the source of light be moved a slight distance farther from the lens, such rays as enter the lens will be a trifle less divergent and after they have been

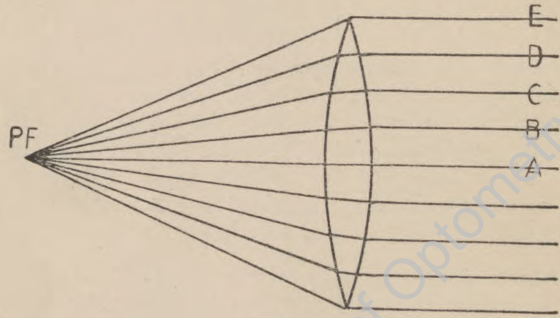

Fig. 1.

paralleled sufficient lens power will remain to focalize them at some point nearer than infinity. If the radiant is near the principal focus, the conjugate focus will be at a remote distance on the opposite side of the lens. As the radiant is made to recede from the lens, its conjugate focus approaches the posterior principal focus. When the radiant arrives at a point two focal lengths from the lens, its conjugate focus will be an equal distance on the opposite side. The radiant inside of the principal focus emits

rays which strike the lens with such divergence that the lens cannot parallel them. In this case no positive conjugate is formed but by tracing the emergent rays backward in straight lines, we may find the point from which they appear to have emanated. This point is on the same side of the lens as the radiant and is a negative or virtual conjugate.

Conjugate foci are illustrated in Fig. 2. The conjugate of A is A′. B is yoked with B′ and C with C′. Thus we see that two conjugate points are not necessarily located on the principal axis but they must be upon the same axis. Since A, B and C are all in the

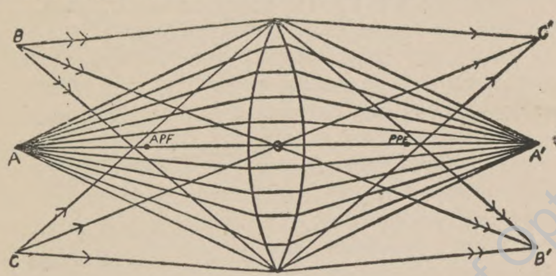

Fig. 2.

same plane, their conjugate foci are also in the same plane. By knowledge of these laws, one may readily locate one of these conjugate points if he knows the other and the focal length of the lens. This principle is utilized in determining the unknown refractive power of the eye by the shadow test. Let us consider the following analogy. Suppose one desires to measure the unknown depth of a hole in the ground. He thrusts a measuring rod of known length into the hole until it touches the bottom then by subtracting that

part which projects out at the top from the total length of the rod, he determines the depth of the hole. Or if the length of the rod is less than the depth of the hole, he measures from its top to the surface of the ground and adds this distance to the length of the rod to find the depth of the hole. To determine the location of a conjugate point in space which is united with the retina of an eye, one makes a calculation which is no more complicated than this, and quite similar. The measuring rod is represented by rays of light which emerge from the pupil. A plus lens placed before the eye intercepts these rays and causes them to focalize at some point in space. This focal distance compared to the principal focal length of the convex lens, provides the data from which the refractive status of the eye may be calculated.

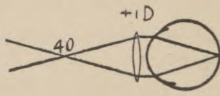

Fig. 3

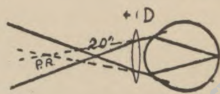

Fig. 4

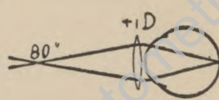

Fig. 5

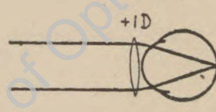

Fig. 6

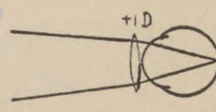

Fig. 7

By way of illustration: let us suppose a plus 1 D. sphere is used before the eye. If the latter is emmetropic, light starting at its retina and emerging from the pupil will proceed in parallel lines to the lens, after which the rays will focalize at the principal focal point of the lens (see Fig. 3). If the eye be 1 D. myopic, the light rays emerging from the eye will be

1 D. convergent and after passing through the lens, would emerge 2 D. convergent and focus at 20 inches. (Fig. 4.) If the eye be hyperopic .50 D. the rays would emerge from the eye .50 divergent and after passing through the lens, would be changed to .50 convergent and focalize at 80 inches. (Fig. 5.) Again, suppose the eye is 1 D. hyperopic. The emergent rays would be 1 divergent when they encounter the lens which would parallel them, sending them through space as a beam (Fig. 6). If the hyperopia be any amount greater than 1 D., the light would leave the lens as a divergent pencil (Fig. 7.)

Equipment.—One cannot understand too thoroughly the fact that adequate equipment is absolutely essential to entire success with this method. A good dark room is the first requisite. It is not necessary to have total darkness, but sufficient to induce the patient's pupil to enlarge and to render the illumination clearly visible by contrast. It is necessary to have a good, bright lamp which provides a solid source of illumination. A small inverted gas lamp or frosted electric lamp with a coiled filament may be found best. It is also advisable to cover the lamp with an asbestos chimney having a small opening by which the illumination may be controlled. Where the electric lamp is used, it may be coated with asbestos cement leaving on one side an exposed area about one inch in diameter, for the opening.

The mirror may be plane or concave and if the essential difference between their effects is understood, the results will be satisfactory with either. It is better, however, to employ but one kind in practice. The plane mirror is generally preferred so we will describe it first.

Plane Mirror.—The plane mirror reflects light without changing the relation of the rays to each other. If they are parallel before reflection, they will be so afterward. If divergent, their divergence will be unchanged. In Fig. 8 the plane mirror AB is receiving divergent light from the lamp and reflecting it in the eye beneath the lamp. The divergence of the rays is just the same when they enter the eye, as if they had traveled the total distance, from the lamp to the mirror then to the eye all in one direction. Some of this light enters the pupil and encounters the retina. It may focus there or not, according to the refractive

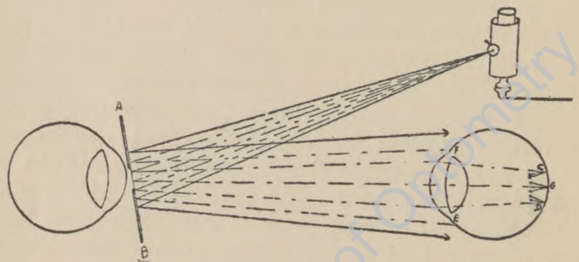

Fig. 8.

condition of the eye, but this is unimportant, as in either case it will illuminate the fundus. That portion of the fundus which receives these rays is known as the illuminated area or light area, illustrated by the space between C and D. Every point of the light area is a source of diffusion from which divergent pencils are thrown off. (Examples C, G, D.) Some of these pencils pass out through the pupil and are

refracted as they emerge from the eye. It is by these emergent rays that the operator may determine the refractive status of the eye under test. If the eye is myopic, the light emerges as a convergent pencil. If hyperopic, as a divergent pencil, and if emmetropic, as a beam, all of this providing accommodation is static.

Reversal Point.—The focal point of the emergent pencil of light is known as the point of reversal and it is the distance of this point from the nodal point of the eye, which we seek to determine. This point cannot be located unless it is positive. Therefore, convex lenses must be placed before the eye. The myopic eye, of course, has a positive far point but the convex lens may be used before these eyes also in determining the refraction. (See Fig. 4.)

Skiametry, then, consists of estimating the refractive status of the eye by the form of the light waves which emerge from it. To see these light waves the examiner's eye must be in their path and he then cannot determine their form except by the effects which they produce upon his own retina. To understand these effects, you must know that they are in the nature of apparent movements of the illumination and shadow which appear in the pupil of the eye under test and which are caused by a slight tilting of the mirror by the operator. Sometimes these movements correspond to the direction in which the mirror is tilted. Again, they move opposite to it. In other cases, no movement may be detected regardless of the tilting of the mirror. Now let us study the following rules.

Rule 1. Retinal Illumination.—The illuminated area which receives the light rays from the mirror.

Rule 2. Shadow.—The dark portion of the retina which surrounds the light area. All of the retina except that within the light area is in shadow.

Rule 3. Real Movement of the Retinal Illumination.—The movement of the light area which actually occurs when the mirror is tilted. If the mirror is plane the light area moves in the direction that the mirror is tilted.

Rule 4. Apparent Movement of the Light Area.—If the focal point of the emergent pencil is between the subject's eye and the mirror, tilting the mirror causes the examiner to see an apparent movement of the light area against the real movement: Thus if the real movement is up, the apparent movement will be down. If the focal point is at the exact nodal point of the observer's eye, there will be no apparent movement, no matter how the mirror is tilted. If the focal point be farther away than the observer's eye, or if it be negative, the apparent movement will be with the real movement.

Rule 5. Point of Reversal.—The myopic far point, or the focal point of the emergent pencil, created in emmetropia and hyperopia by a convex lens. This is the point sought in retinoscopy.

Using the Mirror. We will now study the phenomena caused by tilting a plane mirror in different directions while reflecting light from it into the eye.

Observe Fig. 9. With the mirror held parallel to the eye, as in position B, one ray reflects from it through the nodal point. This ray is the axis, and by tracing it to the fundus, we locate the point of illumination. This ray encounters the mirror at B′ and forms an image of the radiant at B″. If the mirror be tilted back to position A, the point of illumination moves up to A″. This is because the only ray which can reflect through the nodal point, is that which encounters the mirror at A. When the mirror is tilted

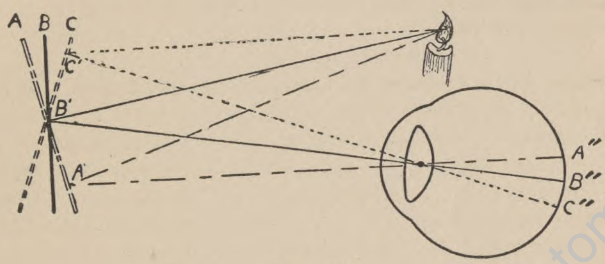

Fig. 9.

down to position C, the only ray which it reflects through the nodal point is the one which encounters it at C′. The point of illumination is at C″. With each change in the position of the mirror, the light area has moved in the same direction as the mirror, thus proving rule 3.

Experiment 1.—Obtain a plane retinoscope and a schematic eye such as is illustrated in the optical catalogs. Hold the mirror with its handle against the cheek, the arm being in an easy position close to the side. Let the mirror rest firmly against the brow and side of the nose in a position which will

bring the aperture directly before your pupil. Practice catching light from the lamp on the mirror and learn to reflect it in different directions until you can control the illumination. Place the schematic eye in a favorable position upon a table. Draw out the tube at the back until it is set at zero (emmetropia). Darken the room, adjust the lamp and try the following:

Fig. 10.

Experiment 2. Measure off a distance of 40 inches. Hold the mirror before your better seeing eye, keeping both eyes open. Direct the light into the pupil of the schematic eye. You should now observe an illumination similar to that illustrated in Fig. 10. The outer portion of the pupil is in shadow, while the central part is illuminated. The cause of this is illustrated in Fig. 11. A divergent pencil starts at B′, emerges from the pupil between the boundary lines X and N. The peripheral rays are stopped by the mirror, while the central ones, all between E and F pass through the opening and into the operator's

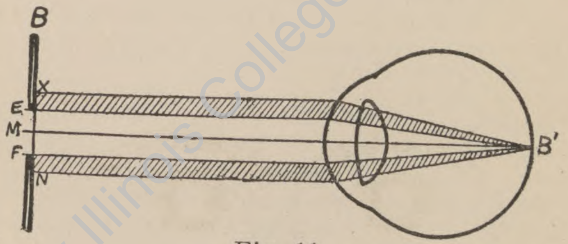

Fig. 11.

eye, assumed to be behind the mirror. The outer portion of the pupil is in shadow because no light proceeding from it enters the observer's eye.

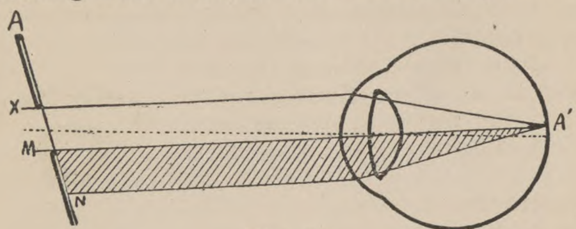

Fig. 12.

Experiment 3.—Tilt the mirror upward to position A as in Fig. 12. By close scrutiny, you may see the light area move up also, causing the pupil to appear bright in its upper portion. The lower part is in shadow. (See Fig. 13.) We have learned that when the plane mirror is tilted up the light area moves up also. Thus in Fig. 12 the source from which the emergent rays come is A'. These rays leave the eye parallel to the axis M, but the entire beam is directed downward so that those rays which emerge from the lower part of the pupil are excluded by the mirror and only those which come from the upper portion pass through the opening to enter the eye of the observer. Therefore, when the mirror is tilted up, the apparent movement is up.

Experiment 4.—Tilt the mirror downward to posi-

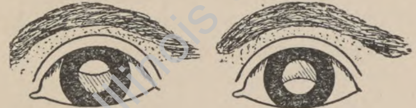

Fig. 13. Fig. 14.

tion C and you will note that the lower part of the pupil becomes bright, while from the upper edge a shadow creeps in to cover the upper portion. This effect is illustrated in Fig. 14, and the cause of it is shown in Fig. 15. It will be observed that those rays which proceed from the eye between lines M and N are visible to the observer, while all of the light between X and M is intercepted by the mirror.

In each of these experiments the illumination has appeared to follow the mirror and as we know the

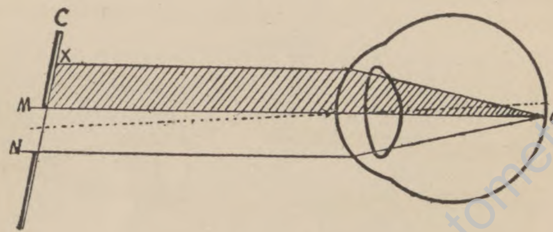

Fig. 15.

real movement of the light area is always with the movement of the plane mirror, it is evident that in this case the apparent movement travels with the real movement as well as with the mirror. When we observe the preceding effect, we cannot know from this fact alone as to the refractive status of the eye. We only know that if this eye has a positive point of reversal, it is located somewhere beyond the operator's working distance.

Shadow in Hyperopia.—Fig. 16 illustrates an eye that is .50 D hyperopic. Light emerging from it passes through a + 1 D. lens. The rays leave this

eye with divergence of .50 D., but after passing through the + 1 D. lens they are .50 D. convergent. If uninterrupted, these rays would focus at a point 80 inches distant. They encounter the operator's mirror, however, at 40 inches. Only the rays between M and N are permitted to pass through the opening, therefore the peripheral portion of the pupil is in shadow while the center appears bright as in Fig. 10. Tilting of the mirror will, in this case, produce movements exactly similar to those previously described. If the mirror be tilted back, the rays from the upper part will pass through the opening of the

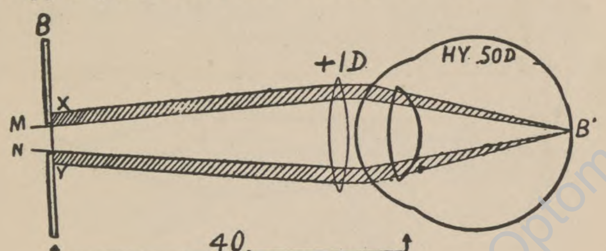

Fig. 16.

mirror as in Fig. 12, while tilting the mirror down causes these rays to be shut off as in Fig. 15. Thus the lower part is illuminated while the upper is in shadow. (See Fig. 14.) In this case also, the apparent and real movements are with the mirror.

Experiment 5.—Set the schematic eye so as to make it .50 D. hyperopic. Place + 1 D. before it and verify the preceding.

Movement Neutralized.—Now let us study the action of the illumination in an emmetropic eye with + 1 D. sphere before it, using a plane mirror at a

distance of 40 inches. (Fig. 17.) The rays emerge from this eye parallel, pass through the + 1 D. and are converted into a pencil which focuses at the nodal point of the observer's eye. In this case, light from every part of the pupil enters the eye of the observer causing the entire pupil to appear luminous. When the mirror is tilted to position A, the light area moves up to A′ and the pencil moves downward until its focus is at A″. The focal point is still in the observer's pupil and consequently no change in the appearance of the illumination is made by tilting the mirror. When the mirror is turned downward to C, the illumination is still unchanged, although the

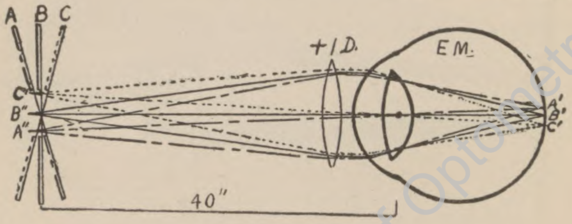

Fig. 17.

focal point of the emergent pencil is now at C″. The pupil still appears to be luminous. If the mirror be tilted any farther than A or C, the entire emergent pencil will be intercepted by the mirror so that no light may pass through the opening and the observed pupil instantaneously appears dark. In this case, no movement of the shadow is visible. So long as the illumination may be seen at all it occupies all parts of the pupil and when it disappears it fades out just as turning off the current from the electric lamp

causes the light to be replaced by darkness. It is this phenomenon which the examiner seeks to detect and he sometimes places lenses before the eyes under test, trying different strengths until he discovers one which creates it. After the fact has been established, that light from the pupil is focused at the working distance, the refractive status may be determined from the lenses which have produced this result. If these are + 1 D. it is proof that the eye is emmetropic, as only parallel rays may pass through a + 1 D. lens and focus at the working distance of 40 inches, and parallel rays emerge from the pupil of none but emmetropic eyes.

Experiment 6.—Adjust the schematic eye to make it emmetropic, place the + 1 D. sphere before it and

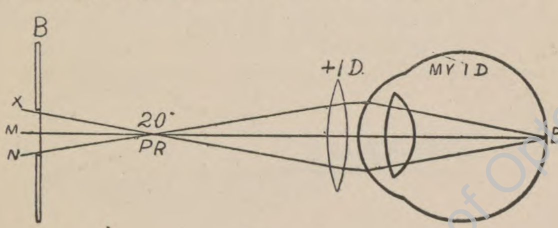

Fig. 18.

demonstrate the effects of a neutralized shadow.

Experiment 7.—Set the schematic eye so that it will register 1 D. of myopia and place before it the + 1 D. sphere. With the mirror in position B, as in Fig. 18, the illumination will be very similar to that of Fig. 17, all portions of the pupil appearing bright. When the mirror is tilted, an interesting effect will be observed. At position A, the upper part of the pupil will be dark, while the lower reveals the il-

lumination. This is illustrated in Fig. 19. We know that tilting the mirror upward causes real movement upward, of the light area. The pencil which emerges from the eye and pases through the lens has its focal point between the lens and the mirror. Thus the rays cross to opposite sides of the axis so that those between M and N are caught upon the mirror

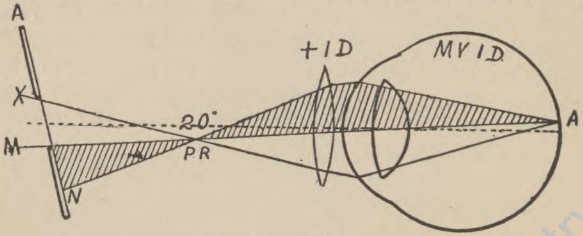

Fig. 19.

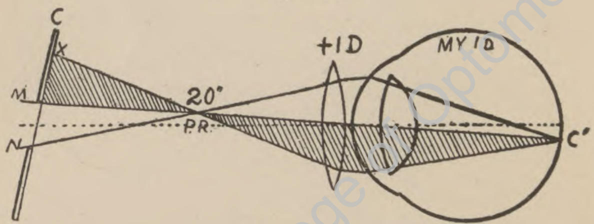

Fig. 20.

while those between X and M pass through the opening. The lower part of the pupil appears illuminated because the rays which enter the observer's eye come entirely from this area. In this instance, the apparent movement is opposite to the real movement, as provided for in rule 4. It is said to have been reversed. Fig. 20 illustrates the effect of tilting the

mirror downward to position C. In this instance it is the light which emerges between M and N which enters the operator's pupil and as this light has come from the upper part of the eye, the lower is left in shadow. In this case also, the apparent movement of the light area is against the real movement, proving the eye to be myopic. By placing a — 1 D. sphere over the convex lens, we may neutralize all movement and create an effect similar to that observed in the experiment illustrated by Fig. 17.

Concave Mirror.—Some optometrists employ the concave retinoscope. Fig. 21 illustrates this instrument being used to illuminate the fundus from three positions.

Concave mirrors form real images, inverted and smaller than the object, located between the principal focus and center of curvature, whenever the object is beyond the center. With the concave mirror held

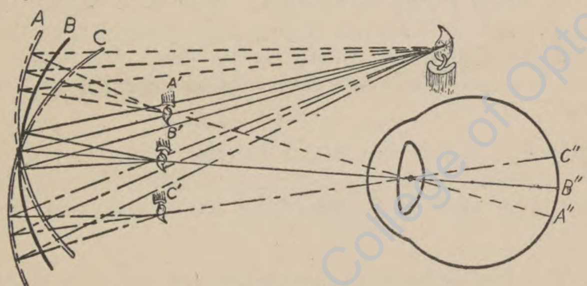

Fig. 21.

in position B, a real image of the source of illumination is located in space at B′. This aerial image may be considered as the source of illumination so that the light area has its center at B″. All of these points

are on the optic axis exactly as they are with the plane mirror in this position.

When the concave mirror is tilted up to position A, the rays which encounter it and reflect through the nodal point of the eye are illustrated by the dotted lines. These form the aerial image of the source at A′, after which they enter the eye and illuminate the fundus at A″. Tilting the mirror to position C, causes the rays to reflect so that only those which travel over the broken lines can enter the eye. These strike the lower part of the mirror, form the aerial image at C′ and illuminate the fundus at C″.

You will note that tilting the concave mirror causes a real movement of the illumination in a direction opposite to that in which the mirror is tilted. When the concave mirror is raised, the real movement is downward. When the concave mirror is lowered, the real movement is upward. For this reason, the apparent movements are opposite in direction to those caused by the plane retinoscope. This fact must be borne in mind when one attempts to practice with the concave mirror.

Rule 6. When the plane mirror is used, the test may be made from any distance which suits the convenience of the operator. The usual distance is 40 inches.

Rule 7.—When, with the plane mirror, the illuminated area and shadow appear to move against the mirror, a minus lens is needed to arrest motion.

Rule 8.--When with the plane mirror, movement is with the mirror, plus lens is needed to neutralize motion.

Rule 9.—When the concave mirror is used, the test must be made from some distance greater than the focal length of the mirror

Rule 10.—When the concave mirror is used, the real movement of the light area is against the movement of the mirror.

Rule 11.—When with the concave mirror, the illuminated area and shadow appear to move with the mirror, minus lens is needed to neutralize motion.

Rule 12.—With the concave mirror movement is against the mirror, plus lens is needed to neutralize motion.

Rule 13.—When with either mirror no motion can be detected, the point of reversal is at the nodal point of the observer's eye.

NOTES

MEASURING OCULAR REFRACTION

CHAPTER II.

As soon as you have attained sufficient skill to neutralize different degrees of error in the schematic eye with test case lenses, you should begin experimentation upon living eyes. In selecting a subject for practice note the color of the iris and size of the pupil. If the color is not too dark and the pupil is large, the red reflex will be more distinct.

Seat your subject where he can fix his eyes upon some object at a distance of 15 or 20 feet and darken the room as much as possible. Adjust the lamp so that its rays cannot fall directly upon your patient's eyes, by placing it either a little to one side or just above his head. Your test case should be on a table at your side. Place the trial frame upon the subject's face. Cover one eye with the opaque disc. Measure off the initial working distance, (40 inches) and proceed with your test. Pass the light slowly across the pupil, first up then down, and learn to judge by one such movement, the action of the shadow. It may require a great deal of practice to train your eye to discern this, but in time, you should learn to accomplish it easily.

Remember the rule: If the movement is against the direction in which you tilt the mirror, the point of reversal is inside of your working distance. If the movement is with the mirror, the reversal point is either beyond your working distance, or is negative, as in hyperopia. In case of with movement, select

from your test case a plus sphere of sufficient power to reverse it decidedly. What this may be you can only determine by trying. After the shadow movement is reversed, either naturally or by means of a convex lens, you may move forward slowly and carefully until you arrive at the exact point of reversal. When you reach this point, measure the distance from your eye to that of the subject. This is best done by means of a piece of tape which is tied to the handle of your mirror and which may be stretched to a point alongside the subject's eye. Or what is better, a small spring-reel tapeline one end of which is attached to the mirror. The other end may be unreeled until the exact distance is measured. When this distance is obtained, in inches or centimeters, convert it into diopters by dividing this quality into a meter, then subtract this dioptric power from the convex lens which you have in the trial frame, and the remainder will indicate the static refraction. Or if the eye was sufficiently myopic for the shadow to appear reversed without recourse to the plus lens, this measurement will determine the amount of myopia.

After completing the test of one eye, insert in the rear cell of the trial frame the lens indicated, transfer the opaque disc to this eye and test the companion eye in similar fashion. When its correcting lens has been found and inserted in the rear cell of the frame, remove the opaque disc and permit both eyes to fix. Your test card should now be illuminated and the patient questioned as to his vision. Take pains to level up the vision by fogging the better eye back to equal the poorer, then prove your correction. If greater amounts of plus lens can be added without blurring the vision, it should be done, in order to

reduce the strain of accommodation to the minimum. On the other hand, if the lenses found with the mirror test do not give normal vision, try every possible plan to improve it to normal, making whatever changes may be necessary.

Skiametry is as subject to interference from accommodative spasm as any other method of testing. Therefore, care must be exercised to induce the greatest possible relaxation of the ciliary muscles. This is what we strive to do when we create the positive reversal point in front of the mirror. It is also important that the patient be cautioned against looking toward the mirror or shifting his gaze toward any object nearer than infinity.

Changing Lenses.—A method sometimes preferred is that of inserting in the rear cell of the trial frame, a + 1 D. sphere in order to bring the working distance (40 inches) into conjugation with the subject's retina and then adding such lenses in the front cell as may be required to bring the point of reversal to 40 inches. By this added lens is determined the static refraction. Sometimes + 3 D. or stronger is placed in the front cell to create a fog and then cancelled with minus spheres, starting with .25 D. and gradually increasing until all movement of the shadow is cancelled, proving that the reversal point has been brought to the 40 inch working distance. This is another application of the fogging system.

Shadow Testing Astigmatism.—Astigmatism reveals itself unmistakably to the optometrist who is trained in skiametry. This error causes a characteristic pupillary reflex, always recognizable by one familiar with it. In simple astigmatism, the pupillary area is crossed by a ribbon or a band of illumination.

(See Fig. 22.) The position of this band indicates the axis of the correcting cylinder. It is not especially difficult to correct this band-like appearance and stop all shadow movement after one detects it. In some instances it is rather obscure.

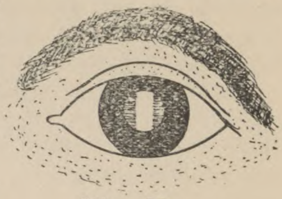

Fig. 22.

In the neutralization of lenses we find that the cylindric element of a compound lens is more difficult to recognize than a plane cylinder uncombined with a sphere. Likewise the eye which has simple astigmatism, exhibits a pupillary reflex, the rectilinear contour of which is much more marked than that of compound or mixed astigmatism. It is more or less difficult to neutralize the cylindric factor of a compound lens until after the spherical portion has been cancelled. So, also, one may fail to observe the band of illumination, indicative of astigmatism until after he has neutralized one principal meridian with a sphere. If, therefore, in the beginning of this test, the pupillary reflex appears as a circle, it would not be conclusive evidence that the eye is entirely free from astigmatism.

Principal Meridians.—As you first flit the light across the pupil you may observe an uncertain movement of the shadow. Neither with nor against, but a sort of revolving motion. This would indicate that you are tilting your mirror in a meridian somewhere between the maximum and minimum curvature. You should endeavor to locate one or the other of the latter, then proceed to neutralize it. Your first purpose should be to find the meridian of least error. After

this meridian has been corrected, the other will continue to show motion which may be stopped, either by a sphere or cylinder.

Applying the Test.—The general rules, previously laid down, should be followed until the preliminary stages have been passed. Cover one eye with the blank disc, place the fogging lens before the other and pass the light across the pupil to determine if your fog is sufficient. Then move carefully forward until you find the reversal point for one meridian. As soon as this point is reached, the pupillary reflex will assume the banded appearance indicative of astigmatism and all motion will cease in the meridian to which the band points. This is the meridian at which the axis of the correcting cylinder should be placed. If the band occupies a vertical position, your cylinder also must have its axis at 90. If at 45, the cylinder axis must be in this meridian. As the movement of the reflex in the second principal meridian is against the plane mirror (because of the fogging lens) it may be stopped by a minus cylinder. This should have just sufficient power to cause the second meridian to show maximum diffusion and absence of motion. Its axis should be placed to correspond exactly with the meridian in which the band first appeared. Carefully measure the distance at which the neutralization of the shadow is most exact and convert it into its dioptric equivalent by dividing into a meter. A minus sphere of this power should be combined with the lenses in the frame to provide a correction for infinity.

Fogging System.—It is obvious then, that the correction of astigmatism by skiametry resolves itself into the measurement of the principal meridians of

the eye. For the purpose of simplicity as well as accuracy we employ the fogging system in all cases except those in which, at the first test, movement is against the mirror in all meridians. In these cases we know the eye to be myopic and we therefore move forward to the point where motion in one principal meridian is neutralized. The reflex will appear diffused in this meridian, indicating it as the position for the axis of the cylinder required to stop motion in the opposite meridian. This cylinder is concave, of the least power which will neutralize motion. Make careful measurement of your working distance, find the dioptric value of this distance by dividing it into a meter. The quotient will indicate the power of the minus sphere which must be added to the combination to give normal vision for infinity.

Compound Hyperopic Astigmatism.—Let us suppose a case requiring the following prescription: + 2 D. S. ⊂ — 1 D. Cyl. axis 180. If a + 4 D. fogging lens be used before this eye, it will cause against motion in all meridians. Starting at 40 inches the operator gradually moves forward watching the reflex and as soon as he arrives at 20 inches it will assume a banded appearance of marked distinctness. In the horizontal meridian there will be maximum diffusion and no motion, while in the vertical meridian the motion is still against the mirror. By starting with a weak concave cylinder axis 180 and gradually increasing, it will be found that a — 1 D. Cyl. axis 180, neutralizes the shadow in the vertical meridian and stops all motion. As the reversal is obtained at 20 inches, the dioptric value of which is 2 D. select a — 2 D. sphere from the case and combine it with the

other lenses to give the proper distance correction.

Simple Hyperopic Astigmatism.—In a case requiring + 1 D. Cyl. axis 45, the test would be applied as follows: Place the blank before one eye and before the other place + 3 D. sphere. This lens causes reversal in all meridians. Move forward until one meridian is neutralized. This will occur at 20 inches. The banded appearance will now point to the 135th meridian and have maximum clearness. A — 1 D. Cyl. axis 135 would cause the entire pupil to appear luminous and stop all motion. After combining with these lenses, the — 2 D. sphere indicated, by the working distance, as being required to lengthen the focus to infinity, the prescription equals + 1 D. S. $\bigcirc$ — 1 D. Cyl. axis 135. These may or may not be transposed, as the operator prefers.

Mixed Astigmatism.—A certain case requires + 2 D. S. $\bigcirc$ — 4 D. Cyl. axis 180. In this instance the luminous band should be visible before any lens is placed before the eye, because the cylinder is stronger than the sphere. As in the other cases, insert sufficient plus sphere to create against motion in all meridians. This would be any amount stronger than 2 D. Suppose in this case we use + 4 D. As the operator moves forward he will again notice reversal in one meridian at the 20 inch distance. The luminous band will now occupy the 180th meridian. He should therefore begin offering minus cylinders axis 180 and increase to — 4 D. Cyl. when the illumination will have become circular and all motion will cease.

Simple and Compound Myopic Astigmatism.—These errors are handled in a manner similar to the foregoing. In these cases, however, the first test

with the mirror may reveal against motion and it will therefore be unnecessary to employ a fogging lens. If, however, the myopia is less than the dioptric value of the working distance, the fogging lens will be required as before.

Irregular Astigmatism.—Any measurement of irregular astigmatism is more or less difficult. On account of the uneven curvature of the cornea or lens, the reflex does not appear equally clear in all portions of the pupillary area, but is more or less obscure in some parts. The operator should endeavor to refract that portion close to the center of the pupil. He may find it necessary to vary his working distance in order to find positions where all portions of the reflex are clear.

Concave Mirror.—In testing all of the preceding conditions with the concave mirror, the operator must make allowance for the fact that with this mirror real movements of the light area are opposite to the movements of the mirror. The same rules govern the use of this mirror in these cases as in the measurement of axial ametropia.

45

NOTES

NOTES

DYNAMIC SKIAMETRY

CHAPTER III.

All optometrists should be familiar with the system of objective testing known as dyamic skiametry. The inventor of this system, Andrew Jay Cross, of New York, has been a student of optometric problems for many years. He devised this method to increase the efficiency of and give added accuracy to drugless refraction.

All methods of sight testing, whether objective or subjective, must take into account the ability of the eye, by accommodation, to alter its refraction. Dynamic skiametry is a test which seeks to control this faculty of the eye during examination. As the author puts it, "dynamic skiametry is the application of retinoscopy under some kind of force." "This force is the muscular one which is familiarly known as accommodation." Static skiametry demands a relaxed ciliary muscle, but the dynamic method strives to induce accommodation to act in definite amounts. The eye that for years has been over-accommodating, often proves difficult to test because it usually persists in this act regardless of the lenses with this the operator strives to subdue it. Partial relaxation, however, may be accomplished in almost every case. Therefore, by the dynamic method, we engage the accommodation in focalizing at a near distance so that such relaxation as is possible, may reveal the latent ametropia. In applying this test, the operator

proceeds exactly as in the static method, except that he attaches to his brow or mirror a card of test letters and directs the subject to read these silently while the test progresses. In this act, the patient must employ both convergence and accommodation, and because of the near relationship which years of associated use has established between these two functions, he will usually continue in some measure to use one as long as he employs the other. The operator places convex lenses before the subject's eyes in an effort to relax accommodation, but the convergent impulse tends to prevent this relaxation below the amount required for the fixation distance. Any accommodation, however, that has been used for the correction of hypermetropia, will the more readily relax for the reason that it becomes more of a burden when the eyes are fixed at near distances, than at infinity.

Greater effort is required to exert either accommodation or convergence by itself than both together. On this account use of one function compels use of the other even though there be no need for it. Place a card over one eye of a subject and hold a pencil where he may fix it with the other. On peering behind the card you will observe that the excluded eye is converging toward practically the same point as that which its companion is fixing. Should it fail to do this, it is usually an indication of muscular imbalance. As accommodation of one eye serves to stimulate accommodation and convergence in both, so convergence serves to stimulate accommodation. It is upon this acquired reflex that dynamic skiametry relies, to prevent over-correction of hyperopia when testing at the near point.

Equipment.—The same dark room and lamp are required as for the static method. If one has not a dynamic skiascope, he should procure one or attach a brow card on the forehead and use a plane retinoscope. In practicing the dynamic method the opaque disc should not be placed over either eye as the two must operate in unison to insure the action of convergence. This is to be the dominating impulse, necessary to the stimulation of accommodation. Though you test but one eye at a time, the correcting lenses may be placed in equal amount before both eyes at once as in many cases this is less likely to disturb the established habits of vision upon which you must in part rely for the success of your test. The dynamic skiascope is equipped with two cards mounted on small side brackets. One is placed a short distance behind the mirror on one side, and the other an equal distance in front of the mirror on the opposite side. During the test the patient's gaze must be fixed upon one or the other of these small test cards, according to the will of the operator.

Several facts must be clearly understood. First: a neutralized shadow will be obtained whenever the subject's fovea is in conjugation with any point in the same plane with the operator's nodal point. Therefore, the subject in fixing your brow card, will, by his own accommodation cause a neutralized shadow, provided he is able to see the letters with maximum distinctness. The test, then, consists of placing before the eyes the strongest convex or weakest concave lenses which in combination with definite accommodation permit maximum clearness of vision at the working distance. Instead of questioning the patient as to this vision, the operator elicits his infor-

mation by observing the movements of the light area and shadow.

If one is somewhat in doubt as to whether or not the shadow is neutralized, he may direct the subject to shift his gaze from one of the mirror test cards to the other. When the patient is fixing the card behind the mirror, the operator's eye is a trifle in front of the fixation distance and a slight "with motion" should be observed. Shifting the gaze to the front card brings the reversal point in front of the operator's eye and causes an "against motion." These exhibits provide a simple proof as to whether or not the subject is properly fixing and focalizing the card.

In practice, the operator should first neutralize the shadow from the distance of 40 inches. If the motion is against the mirror, minus lens should be used until it is neutralized, placing an equal amount of sphere before both eyes. Care must be taken to use the minimum amount of minus lens that will provide this effect, as an over-quantity of concave may tempt accommodation to create false myopia in spite of the tendency of convergence to restrain it. If the movement is "with" or the shadow appears neutralized at the first test, convex lenses should be offered and increased in power until an actual reversal is observed, then the strongest power with which the shadow appears neutral, may be accepted, as a tentative correction.

It is next advisable to move forward to about 20 inches, and repeat the test. The exact distance is not significant as it does not enter into the calculation in prescribing. If the correction found at the first distance is the true one, and measures the static refraction, the shadow will continue to appear neutral at

the nearer distance without change of lenses. The additional convergence required for the shorter distance will usually serve as the stimulus for a like amount of accommodation. Frequently, however, it will be found possible to add a greater amount of plus lens, without reversing the shadow at the near distance. When this occurs it proves one of two things. Either, hyperopia, which at the first test was latent, is now being revealed, or else accommodation is dis-associating itself from convergence and is relaxing under the influence of the convex lens. As to which of these is the true cause, may be determined by moving still farther forward, say to 13 inches. If, at this point no additional plus will be accepted, it would indicate that the test made at 20 inches revealed latent hyperopia and the plus lens now before the eye may be assumed to be the proper measure of the total hyperopia. If, however, moving forward to 13 inches is followed by still further acceptance of convex lens, one may suspect the eye of relaxing below the usual relationship of the ciliaries to the interni, and must prove his correction before prescribing. This, of course, is done anyhow regardless of the indications of the test.

After completing the measurement of one eye its record should be made, the lenses removed from both and the companion eye tested. Again place the correcting lenses before both eyes and increase or decrease them simultaneously.

As soon as the correction for each eye has been ascertained, make no deductions for working distance, but place before each eye the lens indicated, and direct attention to the lighted test chart. If, with these lenses, vision is clear and distinct, an effort should

be made to increase their power .25 D. at a time until the normal type is no longer legible, then reduce to a proper degree of clearness.

If the vision is blurred when the correcting lenses are first put in, it may be ascribed to one of two reasons. Either, latent hyperopia, which was temporarily revealed during the test, is now concealing a portion of the error and causing the blur, or else the accommodation was induced by the plus lenses to yield a certain amount of its normal task through partial disassociation from convergence. Thus the test is in a certain measure indicating the plus lenses acceptable only for the working distance. In the latter case, no amount of effort would enable the patient to wear the correction for infinity. In the former, breaking of the accommodative spasm would permit clear vision with maximum relief from strain. Two methods are open. One, to reduce the lenses to such powers as permit distinct vision, with the expectation of increasing them later, if necessary. The other: to prescribe suppression glasses, the power of which equals the full amount indicated with perhaps an additional .50 D. or .75 D. to be used for constant wear, during a period of several days in order that the spasm of accommodation may be speedily relaxed and the correction for the full error given. This seldom requires more than a week.

Astigmatism is measured in the same manner as in static skiametry. Hence, we need not describe it under this heading.

Hindrances to Accurate Work.—It may be well perhaps, to point out a few of the things which may prevent successful application of dynamic skiametry. The first of these is presbyopia. A presbyope is not a

favorable subject to examine for distance glasses by this method. The natural relationship between accommodation and convergence is always altered in such cases and in total presbyopia no accommodation remains. The static method is therefore used for these cases, and it may be performed with the same equipment.

Severe cases of muscular imbalance may occasionally prevent accuracy by the dynamic method, but this condition is less of a hindrance than might be supposed because whatever the relationship between the interni and ciliaries, it will have existed for a long time and as the functions of focalization and fixation are to be employed during the test, just as they have been used in vision, they will serve to guide each other even though they are not working in strict conformity with the normal relationship unless the derangement is extreme. If the imbalance is such as to disturb binocular single vision, dynamic skiametry, as such, could not be applied literally. The use of plus lenses before such eyes would establish a static condition of the ciliary muscles. Hence allowance for the working distance must be made before prescribing.

It must be remembered that the use of convergence while inhibiting accommodation, is a sleight which some individuals learn more readily than others. Some patients will have acquired the knack of doing this before coming to be tested and this would interfere with the examination. Such cases, however, are rarely subject to spasm of accommodation, and will be found easy to test by the static method.

Dynamic skiametry enables one to dispense with the old 20-foot dark room. Armed with the dynamic

skiascope, one may practice both methods in a room just large enough for comfort. The patient need never fix his gaze on an object more remote than the mirror test card and yet accommodation may be relaxed as completely as where he has a 6 meter distance in which to fix.

Suppose, you wish to test a patient who is blind in one eye. Such a case could not be reliably tested by dynamic skiametry because convergence is not a primary impulse, hence accommodation will relax too far, but this fact need not alter the procedure in testing. The seeing eye should therefore be measured by the static method and on completion of the examination, allowance must be made for the working distance, because this patient would relax the full amount of his error and the amount of his working distance as well; unless held by spasm. Even in the latter case, relaxation is more probable where the focus is fixed on the mirror test card, than where the patient is peering off into space at some dimly lighted chart. Accommodation is controlled by an involuntary muscle and is only to a limited degree, under domination of the will. Its one incentive to relaxaation is the desire for improved vision which this alone can give. If a plus lens creates a blur of some definite object which the eye desires to see, such as the mirror test card, it requires but a moment for the controlling center to comprehend the fact that only by relaxation of the ciliary muscle can this object be attained. Where the static test is made with the fixation chart at the near point in this manner, the fogging method must be employed with great thoroughness until absolute suspension of ciliary effort is reasonably assured then allowance made for the work-

ing distance in exactly the same manner as if the patient's gaze were fixed upon an object at infinity.

If one doubts the possibility of static accommodation in a young individual when fixing at so near a distance, let him consider the fact that every user of the ophthalmoscope must induce this complete relaxation before he can obtain a clear view of his subject's fundus. And just as it requires a certain period of time for one to learn this sleight of accepting the services of the lens system for so near a distance, so the patient who calls at your office will be prone to continue using his eyes in their accustomed way for a sufficient length of time to enable you to successfully apply the dynamic test.

As a final word we would say: go into the dark room prepared to examine every case by either or both methods. Begin every test by dynamic skiametry; direct the patient to fix your card from beginning to end of the test in both methods. Find the strongest plus, or weakest minus, that neutralizes the shadow at 40 inches; then at 20 inches; then at 13 inches. If at the two latter distances the neutralizing power is approximately the same as at the former, you may accept it as practically correct. If it increases as you approach the eye, you would know that your test has devolved into static skiametry and in submitting the lenses in the trial frame for inspection of the distance test card, be prepared to reduce the plus or increase the minus, the amount indicated by the working distance but do not do this until compelled to in order to give maximum distinctness of distance vision.

If one is tempted to raise the objection that there are many exceptions to the rules governing this test,

let him remember that it is the exception to the laws which constitute the difficult portion of every science. The laws themselves are comparatively easy. In dealing with living beings, we are confronted by variable quantities, each of which must perforce be considered as subject to laws peculiar to himself. As some one has said: "Optometric instruments and tests are not like fortune-telling wheels from which by a certain combination you may read the answer." The various tests must be considered as means to an end which cannot be attained except when applied with patience and intelligence. It is an old saying that skiametry may be mastered by the application of twenty rules. The first is—**practice**, the other nineteen,—**practice.**

NOTES

NOTES

OCULO-DIDACTICS

EYE CULTURE

AS USED BY THE AUTHOR AND ORIGINATOR IN PUBLIC SCHOOLS, COLLEGES AND STATE INSTITUTIONS AND PRIVATE PRACTICE FOR OVER FORTY YEARS

BY

CHARLES H. TAYLOR

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NOTES

MUSCULAR ANOMALIES

A NEW THEORY OF ASSOCIATION BETWEEN THE OCULAR MUSCLES AND NERVES FOR THEIR FUNCTIONAL ACTIVITIES.

BY

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